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APPENDIX A

EQUATIONS AND PARAMETERS IN THE IEUBKwin MODEL

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The parameters and equations presented here are not a line-by-line documentation of the IEUBKwin model source code. Although most of the symbols and notations are identical to the model source code, some notations may differ but are mathematically equivalent. The equations and parameters presented in this document have been simplified for clarity. All the equations, with the exception of those listed below, were taken from the *Technical Support Document (TSD*): *Parameters and Equations Used in the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children* (v 0.99d) [December 1994]. The TSD (December 1994) is an update of the TSD (July 1994) and was prepared and reviewed by the Technical Review Workgroup for Lead (TRW).

Appendix A consists of three tables which contain the equations used in the IEUBKwin model. Exposure equations are listed in Table A-1. Tables A-2 and A-3 contain the equations for the uptake and biokinetic components, respectively. Within each table, similar equations or equations which combine to achieve a common purpose are grouped together. For example, in Table A-1, the equation groups are defined by the different environmental media.

For Equation E-2, the parameter out_air_concentration in the TSD has been changed to air_concentration in response to a recommendation made during the Independent Verification and Validation (IV&V) to make this parameter consistent with the model source code. In addition, the parameter EXAIR has been changed to INAIR. Simplified versions of the Equations E-8 and E-11 were presented in Appendix A of the TSD (December 1994). However, for clarity, completeness, and improved functionality of IEUBKwin model, the various forms of Equation E-8 and Equation E-11 were added to Appendix A. The IV&V findings regarding differences between the model source code and the TSD recommended the value 65.67 in Equation B-5j be changed to 65.37 to be consistent with the model source code.

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TABLE A-1. EQUATIONS OF THE EXPOSURE MODEL COMPONENT		
GROUP	**NUMBER**	**EQUATION**
Air Lead	E-1	IndoorConc[AGE] = 0.01 * indoorpercent * air_concentration[AGE]
	E-2	$$\text{TWA[AGE]} = \frac{[\text{time\_out[AGE]} * \text{air\_concentration[AGE]}] + [(24 - \text{time\_out[AGE]}) * \text{IndoorConc[AGE]}]}{24}$$
	E-3	INAIR[AGE] = TWA[AGE] * vent_rate[AGE]
Dietary Lead	E-4a E-4b E-4c	INDIET[AGE] = diet_intake[AGE] *or* INDIET[AGE] = DietTotal[AGE] = *InOtherDiet[AGE]*+ InMeat[AGE] + InGame[AGE] + InHomeFish[AGE] + InCanVeg[AGE] + InFrVeg[AGE] + InHomeVeg[AGE] + InCanFruit[AGE] + InFrFruit[AGE] + InHomeFruit[AGE] InOtherDiet[AGE] = InDairy[AGE] + InJuice[AGE] + InNuts[AGE] + InBread[AGE] + InPasta[AGE] + InBeverage[AGE] + InCandy[AGE] + InSauce[AGE] + InFormula[AGE] + InInfant[AGE]

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years;, [MONTH] = 0–84; [NS] = .iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-1. EQUATIONS OF THE EXPOSURE MODEL COMPONENT—*Continued*

GROUP	NUMBER	EQUATION
Dietary Lead (continued)	E-5a	InMeat[AGE] = (1 - userFishFraction - userGameFraction) * meat[AGE]
	E-5b	InCanVeg[AGE] = (1 - userVegFraction) * can_veg[AGE]
	E-5c	InFrVeg[AGE] = (1 - userVegFraction) * f_veg[AGE]
	E-5d	InCanFruit[AGE] = (1 - userFruitFraction) * can_fruit[AGE]
	E-5e	InFrFruit[AGE] = (1 - userFruitFraction) * f_fruit[AGE]
	E-5f	InHomeFruit[AGE] = userFruitFraction * home_fruit_consump[AGE] * UserFruitConc
	E-5g	InHomeVeg[AGE] = userVegFraction * home_veg_consump[AGE] * UserVegConc
	E-5h	InHomeFish[AGE] = userFishFraction * meat_consump[AGE] * UserFishConc
	E-5i	InGame[AGE] = userGameFraction * meat_consump[AGE] * UserGameConc
	E-5j	InDairy[AGE] = Dairy[AGE]
	E-5k	InJuice[AGE] = Juices[AGE]
	E-5l	InNuts[AGE] = Nuts[AGE]
	E-5m	InBread[AGE] = Bread[AGE]
	E-5n	InPasta[AGE] = Pasta[AGE]
	E-5o	InBeverage[AGE] = Beverage[AGE]
	E-5p	InCandy[AGE] = Candy[AGE]
	E-5q	InSauce[AGE] = Sauce[AGE]
	E-5r	InFormula[AGE] = Formula[AGE]
	E-5s	InInfant[AGE] = Infant[AGE]

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[AGE] = 0–7 years;, [MONTH] = 0–84; [NS] = .iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-1. EQUATIONS OF THE EXPOSURE MODEL COMPONENT—*Continued*

GROUP	NUMBER	EQUATION
Water Lead	E-6a *or*	INWATER[AGE] = water_consumption[AGE] * constant_water_conc
	E-6b	INWATER[AGE] = water_consumption[AGE] * constant_water_concorINWATER[AGE] = water_consumption[AGE] * (HomeFlushedConc * HomeFlushedFraction + FirstDrawConc * FirstDrawFraction + FountainConc * FountainFraction)
	E-7	*HomeFlushedFraction = 1 - FirstDrawFraction - FountainFraction*
Soil Lead	E-8a E-8b	INSOIL[AGE] = constant_soil_conc[AGE] * soil_ingested[AGE] * (0.01 * weight_soil) *or* INSOIL[AGE] =soil_content[AGE]* soil_ingested[AGE] * (0.01 * weight_soil)
Dust Lead	E-9a	INDUST[AGE] = constant_dust_conc[AGE] * soil_ingested[AGE] * [0.01 * (100 - weight_soil)]
	E-9b	INDUST[AGE] = DustTotal[AGE] * soil_indoor[AGE] * HouseFraction
	E-9c	INDUSTA[AGE] = OCCUP[AGE] + SCHOOL[AGE] + DAYCARE[AGE] + SECHOME[AGE] + OTHER[AGE]
	E-9d	INDUST[AGE] = soil_indoor[AGE] * soil_ingested[AGE] * [0.01 * (100 - weight_soil)]
	E-9e	INDUST[AGE] = dust_indoor[AGE] * soil_ingested[AGE] * (0.01 * (100 - weight_soil))
	E-9.5	*HouseFraction = 1 - OccupFraction - SchoolFraction - DaycareFraction - SecHomeFraction - OtherFraction*
	E-10	DustTotal[AGE] = soil_ingested[AGE] * (0.01 * (100 - weight_soil))
	E-11a	soil_indoor[AGE] = [(contrib_percent *soil_content[AGE]) + (multiply_factor * air_concentration[AGE]]
	E-11b	soil_indoor[AGE] = [contrib_percent * constant_soil_conc[AGE]] + [(multiply_factor * air_concentration[AGE]]
	E-11c	soil_indoor[AGE] = dust_indoor[AGE]
	E-11d	soil_indoor[AGE] = constant_dust_conc[AGE]

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[AGE] = 0–7 years;, [MONTH] = 0–84; [NS] = .iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-1. EQUATIONS OF THE EXPOSURE MODEL COMPONENT—*Continued*

GROUP	NUMBER	EQUATION
Dust Lead	E-12a	OCCUP[AGE] = DustTotal[AGE] * OccupFraction * OccupConc
	E-12b	SCHOOL[AGE] = DustTotal[AGE] * SchoolFraction * SchoolConc
	E-12c	DAYCARE[AGE] = DustTotal[AGE] * DaycareFraction * DaycareConc
	E-12d	SECHOME[AGE] = DustTotal[AGE] * SecHomeFraction * SecHomeConc
	E-12e	OTHER[AGE] = DustTotal[AGE] * OtherFraction *OtherConc

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[AGE] = 0–7 years;, [MONTH] = 0–84; [NS] = .iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-2. EQUATIONS OF THE UPTAKE MODEL COMPONENT		
GROUP	**NUMBER**	**EQUATION**
Absorption Coefficients, Passive Uptakes		
		Note: In calculating uptake, first, medium-specific passive uptakes are calculated using equations U1a-U1f, then, the medium-specific passive uptake values are updated with the inclusion of the active uptake contribution using equations U1g-U1l.
Dust Lead (continued)	U-1a	$UPDIET[MONTH] = PAF * ABSF * AVF * INDIET[AGE]$
	U-1b	$UPWATER[MONTH] = PAF * ABSW * AVW * INWATER[AGE]$
	U-1c	$UPDUST[MONTH] = PAF * ABSD * AVD * INDUST[AGE]$

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[AGE] = 0–7 years;, [MONTH] = 0–84; [NS] = .iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-2. EQUATIONS OF THE UPTAKE MODEL COMPONENT—*Continued*		
GROUP	**NUMBER**	**EQUATION**
Absorption Coefficients, Passive Uptakes *(continued)*		
Dust Lead (continued)	U-1d	UPDUSTA[MONTH] = PAF * ABSD * AVD * INDUSTA[AGE]
	U-1e	UPSOIL[MONTH] = PAF * ABSS * AVS * INSOIL[AGE]
	U-1f	UPOTHER[MONTH] = PAF * ABSO * AVO * INOTHER[AGE]

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years;, [MONTH] = 0–84; [NS] = .iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-2. EQUATIONS OF THE UPTAKE MODEL COMPONENT—*Continued*		
GROUP	**NUMBER**	**EQUATION**
Absorption Coefficients, Active Uptakes		
Dust Lead (continued)	U-1g	$UPDIET[MONTH] = UPDIET[MONTH] + \left[\dfrac{(1 - PAF) * ABSF * AVF * INDIET[AGE]}{1 + \dfrac{UPPOTEN[MONTH]}{SATUPTAKE[MONTH]}}\right]$
	U-1h	$UPWATER[MONTH] = UPWATER[MONTH] + \left[\dfrac{(1 - PAF) * ABSW * AVW * INWATER[AGE]}{1 + \dfrac{UPPOTEN[MONTH]}{SATUPTAKE[MONTH]}}\right]$
	U-1i	$UPDUST[MONTH] = UPDUST[MONTH] + \left[\dfrac{(1 - PAF) * ABSD * AVD * INDUST[AGE]}{1 + \dfrac{UPPOTEN[MONTH]}{SATUPTAKE[MONTH]}}\right]$

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years;, [MONTH] = 0–84; [NS] = .iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-2. EQUATIONS OF THE UPTAKE MODEL COMPONENT—*Continued*		
GROUP	**NUMBER**	**EQUATION**
Absorption Coefficients, Active Uptakes *(continued)*		
Dust Lead (continued)	U-1j	$$\text{UPDUSTA[MONTH]} = \text{UPDUSTA[MONTH]} + \left[\frac{(1 - \text{PAF}) * \text{ABSD} * \text{AVD} * \text{INDUSTA[AGE]}}{1 + \frac{\text{UPPOTEN[MONTH]}}{\text{SATUPTAKE[MONTH]}}} \right]$$
	U-1k	$$\text{UPSOIL[MONTH]} = \text{UPSOIL[MONTH]} + \left[\frac{(1 - \text{PAF}) * \text{ABSS} * \text{AVS} * \text{INSOIL[AGE]}}{1 + \frac{\text{UPPOTEN[MONTH]}}{\text{SATUPTAKE[MONTH]}}} \right]$$
	U-1l	$$\text{UPOTHER[MONTH]} = \text{UPOTHER[MONTH]} + \left[\frac{(1 - \text{PAF}) * \text{ABSO} * \text{AVO} * \text{INOTHER[AGE]}}{1 + \frac{\text{UPPOTEN[MONTH]}}{\text{SATUPTAKE[MONTH]}}} \right]$$

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years;, [MONTH] = 0–84; [NS] = .iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

GROUP	NUMBER	EQUATION
TABLE A-2. EQUATIONS OF THE UPTAKE MODEL COMPONENT—*Continued*		
Absorption Coefficients *(continued)*	U-2	UPPOTEN = ABSD * INDUST[AGE] + ABSD * INDUSTA[AGE] + ABSS * INSOIL[AGE] + ABSF * INDIET[AGE] + ABSO * INOTHER[AGE] + ABSW * INWATER[AGE]
	U-3	$SATUPTAKE[MONTH] = SATUPTAKE2 * \left[\frac{WTBODY[MONTH]}{WTBODY[24]}\right]$
Total Lead Uptake	U-4	UPAIR[MONTH] = air_absorp[AGE]*0.01*INAIR[AGE]
	U-5	UPTAKE[MONTH] = 30*{(UPDIET[MONTH] + UPWATER[MONTH] + UPDUST[MONTH] + UPSOIL[MONTH] + UPDUSTA[MONTH] + UPOTHER[MONTH] + UPAIR[MONTH]}

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years;, [MONTH] = 0–84; [NS] = .iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT		
GROUP	**NUMBER**	**EQUATION**
Compartmental Lead Transfer Times	B-1a	$TBLUR[MONTH] = TBLUR[24] * \left(\frac{WTBODY[MONTH]}{WTBODY[24]}\right)^{0.333}$
	B-1b	$TBLLIV[MONTH] = TBLLIV[24] * \left(\frac{WTBODY[MONTH]}{WTBODY[24]}\right)^{0.333}$
	B-1c	$TBLOTH[MONTH] = TBLOTH[24] * \left(\frac{WTBODY[MONTH]}{WTBODY[24]}\right)^{0.333}$
	B-1d	$TBLKID[MONTH] = TBLKID[24] * \left(\frac{WTBODY[MONTH]}{WTBODY[24]}\right)^{0.333}$
	B-1e	$TBLBONE[MONTH] = TBLBONE[24] * \left(\frac{WTBODY[MONTH]}{WTBODY[24]}\right)^{0.333}$

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years;, [MONTH] = 0–84; [NS] = .iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT *(continued)*		
GROUP	**NUMBER**	**EQUATION**
Compartmental Lead Transfer Times *(continued)*	B-1f	TBLFEC[MONTH] = RATFECUR * TBLUR[MONTH]
	B-1g	TBLOUT[MONTH] = RATOUTFEC * TBLFEC[MONTH]
	B-1h	$\text{TBONEBL[MONTH]} = \text{CRBONEBL[MONTH]} * \text{TBLBONE[MONTH]} * \left[\dfrac{\{\text{WTTRAB[MONTH]} + \text{WTCORT[MONTH]}\}}{\left(\dfrac{\text{VOLBLOOD[MONTH]}}{10}\right)}\right]$
	B-2a	$\text{TPLRBC} = 0.1$
	B-2b	$\text{TRBCPL} = \text{TPLRBC} * \left[\text{RATBLPL} - \dfrac{0.55}{(0.55 + 0.73)}\right]$
	B-2c	$\text{TPLUR[MONTH]} = \dfrac{\text{TBLUR[MONTH]}}{\text{RATBLPL}}$

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TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT *(continued)*		
GROUP	**NUMBER**	**EQUATION**
Compartmental Lead Transfer Times *(continued)*	B-2d	$TPLLIV[MONTH] = \frac{TBLLIV[MONTH]}{RATBLPL}$
	B-2e	$TLIVPL[MONTH] = CRLIVBL[MONTH] * \left[\frac{TBLLIV[MONTH]}{\left(1 - \frac{TBLLIV[MONTH]}{TBLFEC[MONTH]}\right)}\right] * \left[\frac{WTLIVER[MONTH]}{\left(\frac{VOLBLOOD[MONTH]}{10}\right)}\right]$
	B-2f	$TLIVFEC[MONTH] = CRLIVBL[MONTH] * TBLFEC[MONTH] * \left[\frac{WTLIVER[MONTH]}{\left(\frac{VOLBLOOD[MONTH]}{10}\right)}\right]$
	B-2g	$TPLKID[MONTH] = \frac{TBLKID[MONTH]}{RATBLPL}$
	B-2h	$TKIDPL[MONTH] = CRKIDBL[MONTH] * TBLKID[MONTH] * \left[\frac{WTKIDNEY[MONTH]}{\left(\frac{VOLBLOOD[MONTH]}{10}\right)}\right]$
	B-2i	$TPLTRAB[MONTH] = \frac{TBLBONE[MONTH]}{(0.2 * RATBLPL)}$

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TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT *(continued)*		
GROUP	**NUMBER**	**EQUATION**
Compartmental Lead Transfer Times (continued)	B-2j	$TTRABPL[MONTH] = TBONEBL[MONTH]$
	B-2k	$TPLCORT[MONTH] = \frac{TBLBONE[MONTH]}{(0.8 * RATBLPL)}$
	B-2l	TCORTPL[MONTH] = TBONEBL[MONTH]
	B-2m	$TPLOTH[MONTH] = \frac{TBLOTH[MONTH]}{RATBLPL}$
	B-2n	$TOTHPL[MONTH] = CROTHBL[MONTH] * \left[\frac{TBLOTH[MONTH]}{\left(1 - \frac{TBLOTH[MONTH]}{TBLOUT[MONTH]}\right)}\right] * \left[\frac{WTOTHER[MONTH]}{\left(\frac{VOLBLOOD[MONTH]}{10}\right)}\right]$
	B-2o	$TOTHOUT[MONTH] = CROTHBL[MONTH] * TBLOUT[MONTH] * \left[\frac{WTOTHER[MONTH]}{\left(\frac{VOLBLOOD[MONTH]}{10}\right)}\right]$
	B-2.5	$TPLRBC2[STEPS] = \frac{TPLRBC}{\left[1 - \frac{MRBC[STEPS]}{(VOLRBC([MONTH]-1) * CONRBC)}\right]}$

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TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT *(continued)*		
GROUP	**NUMBER**	**EQUATION**
Blood to Plasma-ECF Lead Mass Ratio	B-3	RATBLPL = 100
Fluid Volumes and Organ Weights	B-4a	CRKIDBL[MONTH] = 0.777 + [2.35 * {1 - exp(-0.0468*[MONTH])}]
	B-4b	CRLIVBL[MONTH] = 1.1 + [3.5 * {1 - exp(-0.0462*[MONTH])}]
	B-4c	CRBONEBL[MONTH] = 6.0 + [215.0 * {1 - exp(-0.000942*[MONTH])}]
	B-4d	CROTHBL[MONTH] = 0.931 + [0.437 * {1 - exp(-0.00749*[MONTH])}]
	B-5a	$\text{VOLBLOOD[MONTH]} = \left[\frac{10.67}{1+\exp\left\{-\frac{([\text{MONTH}]-6.87)}{7.09}\right\}}\right] + \left[\frac{21.86}{1+\exp\left\{-\frac{([\text{MONTH}]-88.15)}{26.73}\right\}}\right]$
	B-5b	$\text{VOLRBC[MONTH]} = \left[\frac{4.31}{1+\exp\left\{-\frac{([\text{MONTH}]-6.45)}{10.0}\right\}}\right] + \left[\frac{26.47}{1+\exp\left\{-\frac{([\text{MONTH}]-129.61)}{25.98}\right\}}\right]$
	B-5c	$\text{VOLPLASM[MONTH]} = \left[\frac{6.46}{1+\exp\left\{-\frac{([\text{MONTH}]-6.81)}{5.74}\right\}}\right] + \left[\frac{8.83}{1+\exp\left\{-\frac{([\text{MONTH}]-65.66)}{23.62}\right\}}\right]$
	B-5d	VOLECF[MONTH] = 0.73 * VOLBLOOD[MONTH]

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TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT *(continued)*		
GROUP	**NUMBER**	**EQUATION**
Fluid Volumes and Organ Weights *(continued)*	B-5e	$WTECF[MONTH] = 0.73 * \frac{VOLBLOOD[MONTH]}{10}$
	B-5f	$WTBODY[MONTH] = \left[\frac{8.375}{1 + \exp\left\{-\frac{([MONTH]-3.80)}{3.60}\right\}}\right] + \left[\frac{17.261}{1 + \exp\left\{-\frac{([MONTH]-48.76)}{20.63}\right\}}\right]$
	B-5g	WTBONE[MONTH] = 0.111 * WTBODY[MONTH] [MONTH] ≤ 12 months = 0.838 + 0.02 * [MONTH] [MONTH] > 12 months
	B-5h	WTCORT = 0.8*WTBONE[MONTH]
	B-5i	WTTRAB = 0.2*WTBONE[MONTH]
	B-5j	$WTKIDNEY[MONTH] = \left[\frac{0.050}{1 + \exp\left\{-\frac{([MONTH]-5.24)}{4.24}\right\}}\right] + \left[\frac{0.106}{1 + \exp\left\{-\frac{([MONTH]-65.37)}{34.11}\right\}}\right]$
	B-5k	$WTLIVER[MONTH] = \left[\frac{0.261}{1 + \exp\left\{-\frac{([MONTH]-9.82)}{3.67}\right\}}\right] + \left[\frac{0.584}{1 + \exp\left\{-\frac{([MONTH]-55.65)}{37.64}\right\}}\right]$

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TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT *(continued)*		
GROUP	**NUMBER**	**EQUATION**
Fluid Volumes and Organ Weights *(continued)*	B-5l	WTOTHER[MONTH] = WTBODY[MONTH] - WTKIDNEY[MONTH] - WTLIVER[MONTH] - WTTRAB[MONTH] - WTCORT[MONTH] - WTBLOOD[MONTH] - WTECF[MONTH]
	B-5m	$WTBLOOD[MONTH] = 1.056 * \frac{VOLBLOOD[MONTH]}{10}$

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TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT *(continued)*

GROUP	NUMBER	EQUATION
		NOTE: The following equations (B-6a to B-6i) represent the correct mathematical specification. These differential equations are translated into difference equations employing the backward Euler solution in the series B-6.5a to B-6.5i (an algebraic rearrangement presented for ease of interpretation). The calculations are shown in B-9a–B9i.
Compartmental Lead Masses (Differential Equations)	B-6a	dMPLECF(STEPS)/dt = UPTAKE(STEPS) + *INFLOW(STEPS)* - *OUTFLOW(STEPS)*
	B-6b	$\text{INFLOW(STEPS)} = \frac{\text{MLIVER[STEPS]}}{\text{TLIVPL[MONTH]}} + \frac{\text{MKIDNEY[STEPS]}}{\text{TKIDPL[MONTH]}} + \frac{\text{MOTHER(STEPS)}}{\text{TOTHPL[MONTH]}} + \frac{\text{MTRAB(STEPS)}}{\text{TTRABPL[MONTH]}} + \frac{\text{MCORT[STEPS]}}{\text{TCORTPL[MONTH]}} + \frac{\text{MRBC[ST}}{\text{TRBCPL[MC}}$
	B-6c	$\text{OUTFLOW[STEPS]} = \text{MPLECF[STEPS]} * \left[\frac{1}{\text{TPLUR[MONTH]}} + \frac{1}{\text{TPLLIV[MONTH]}} + \frac{1}{\text{TPLKID[MONTH]}} + \frac{1}{\text{TPLOTH[MONTH]}} + \frac{1}{\text{TPLTRAB[MONTH]}} + \frac{1}{\text{TPLCORT[MONTH]}} + \frac{1}{\text{TPLRBC2[MONTH}}\right.$
	B-6d	$\frac{\text{dMRBC[STEPS]}}{\text{dt}} = \frac{\text{MPLECF[STEPS]}}{\text{TPLRBC2[MONTH]}} - \frac{\text{MRBC[STEPS]}}{\text{TRBCPL[MONTH]}}$
	B-6e	$\frac{\text{dMLIVER[STEPS]}}{\text{dt}} = \frac{\text{MPLECF[STEPS]}}{\text{TPLLIV[MONTH]}} - \text{MLIVER[STEPS]} * \left[\frac{1}{\text{TLIVPL[MONTH]}} + \frac{1}{\text{TLIVFEC[MON}}\right.$
	B-6f	$\frac{\text{dMKIDNEY[STEPS]}}{\text{dt}} = \frac{\text{MPLECF[STEPS]}}{\text{TPLKID[MONTH]}} - \frac{\text{MKIDNEY[STEPS]}}{\text{TKIDPL[MONTH]}}$

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years;, [MONTH] = 0–84; [NS] = .iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT *(continued)*

GROUP	NUMBER	EQUATION
Compartmental Lead Masses (Differential Equations) *(continued)*	B-6g	$\frac{dMOTHER[STEPS]}{dt} = \frac{MPLECF[STEPS]}{TPLOTH[MONTH]} - MOTHER[STEPS] * \left[\frac{1}{TOTHPL[MONTH]} + \frac{1}{TOTHOUT[MONTH]}\right]$
	B-6h	$\frac{dMTRAB[STEPS]}{dt} = \frac{MPLECFSTEPS]}{TPLTRAB[MONTH]} - \frac{MTRAB[STEPS]}{TTRABPL[MONTH]}$
	B-6i	$\frac{dMCORT[STEPS]}{dt} = \frac{MPLECF[STEPS]}{TPLCORT[MONTH]} - \frac{MCORT[STEPS]}{TCORTPL[MONTH]}$
	B-6.5a	$\frac{MPLECF[STEPS] - MPLECF(STEPS-NS)}{NS} = UPTAKE[MONTH] + INFLOW[STEPS] - OUTFLOW[STEPS]$
	B-6.5b	$INFLOW[STEPS] = \frac{MLIVER[STEPS]}{TLIVPL[MONTH]} + \frac{MKIDNEY[STEPS]}{TKIDPL[MONTH]} + \frac{MOTHER[STEPS]}{TOTHPL[MONTH]} + \frac{MTRAB[STEPS]}{TTRABPL[MONTH]} + \frac{MCORT[STEPS]}{TCORTPL[MONTH]} + \frac{MRBC[STE}{TRBCPL}$
	B-6.5c	

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TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT *(continued)*		
GROUP	**NUMBER**	**EQUATION**
		$OUTFLOW[STEPS] = MPLECF[STEPS] * \left[\frac{1}{TPLUR[MONTH]} + \frac{1}{TPLLIV[MONTH]} + \frac{1}{TPLKID[MONTH]} + \frac{1}{TPLOTH[MONTH]} + \frac{1}{TPLTRAB[MONTH]} + \frac{1}{TPLCORT[MONTH]} + \frac{1}{TPLRBC2[MONTH]}\right]$
Compartmental Lead Masses (Differential Equations) *(continued)*	B-6.5d	$\frac{MRBC[STEPS] - MRBC([STEPS]-NS)}{NS} = \frac{MPLECF[STEPS]}{TPLRBC2[MONTH]} - \frac{MRBC[STEPS]}{TRBCPL}$
	B-6.5e	$\frac{MLIVER[STEPS] - MLIVER([STEPS]-NS)}{NS} = \frac{MPLECF[STEPS]}{TPLLIV[MONTH]} - MLIVER[STEPS] * \left[\frac{1}{TLIVPL[MONTH]} + \frac{1}{TLIVFEC[MONTH]}\right]$
	B-6.5f	$\frac{MKIDNEY[STEPS] - MKIDNEY([STEPS]-NS)}{NS} = \frac{MPLECF[STEPS]}{TPLKID[MONTH]} - \frac{MKIDNEY[STEPS]}{TKIDPL[MONTH]}$
	B-6.5g	$\frac{MOTHER[STEPS] - MOTHER([STEPS]-NS)}{NS} = \frac{MPLECF[STEPS]}{TPLOTH[MONTH]} - MOTHER[STEPS] * \left[\frac{1}{TOTHPL[MONTH]} + \frac{1}{TOTHOUT[MONTH]}\right]$
	B-6.5h	$\frac{MTRAB[STEPS] - MTRAB([STEPS]-NS)}{NS} = \frac{MPLECF[STEPS]}{TPLTRAB[MONTH]} - \frac{MTRAB[STEPS]}{TTRABPL[MONTH]}$

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years;, [MONTH] = 0–84; [NS] = .iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT *(continued)*		
GROUP	**NUMBER**	**EQUATION**
	B-6.5i	$\frac{MCORT[STEPS] - MCORT([STEPS] - NS)}{NS} = \frac{MPLECF[STEPS]}{TPLCORT[MONTH]} - \frac{MCORT[STEPS]}{TCORTPL[MONTH]}$

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years;, [MONTH] = 0–84; [NS] = .iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT *(continued)*		
GROUP	**NUMBER**	**EQUATION**
		NOTE: Equations B-7b, B-7c, and B-7d represent the distribution of fetal blood lead, derived from the mother's blood lead, at birth. In this simplified form, these equations are numerically equivalent to the following equations that more precisely represent the distribution of lead at birth. The difference in these two sets of equations is insignificant after 2-3 iteration steps.
Tissue Lead Masses and Blood Lead Concentration at Birth		$MPLECF(0) = \dfrac{PBBLD0 * (VOLPLASM(0) + VOLRBC(0)) * \left(\dfrac{TPLRBC}{NS}\right)}{\left(\dfrac{TRBCPL(0)}{NS}\right)}$
		$MRBC(0) = PBBLD0 * (VOLPLASM(0) + VOLRBC(0)) * \left[1 - 0.416\left(\dfrac{TPLRBC(0)}{TRBCPL(0)}\right)\right]$
		$MPLASM(0) = \dfrac{MPLECF(0)}{0.416}$
	B-7a	PBBLD0 = 0.85 * PBBLDMAT
	B-7b	$MPLECF(0) = \dfrac{PBBLD0 * (VOLPLASM(0) + VOLRBC(0)) * \left(\dfrac{TPLRBC}{NS}\right) * (1.7 - HCT0)}{\left(\dfrac{TRBCPL(0)}{NS} + \dfrac{TPLRBC}{NS}\right)}$

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years;, [MONTH] = 0–84; [NS] = .iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT *(continued)*

GROUP	NUMBER	EQUATION
Tissue Lead Masses and Blood Lead Concentration at Birth *(continued)*	B-7c	$\mathrm{MRBC(0)} = \dfrac{\mathrm{PBBLD0} * (\mathrm{VOLPLASM(0)} + \mathrm{VOLRBC(0)}) * \left(\dfrac{\mathrm{TRBCPL(0)}}{\mathrm{NS}}\right)}{\left(\dfrac{\mathrm{TRBCPL(0)}}{\mathrm{NS}} + \dfrac{\mathrm{TPLRBC}}{\mathrm{NS}}\right)}$
	B-7d	$\mathrm{MPLASM(0)} = \dfrac{\mathrm{MPLECF(0)}}{(1.7 - \mathrm{HCT0})}$
	B-7e	MCORT(0) = 78.9 ** PBBLD0 * WTCORT(0)
	B-7f	MKIDNEY(0) = 10.6 * PBBLD0 * WTKIDNEY(0)
	B-7g	MLIVER(0) = 13.0 * PBBLD0 * WTLIVER(0)
	B-7h	MOTHER(0) = 16.0 * PBBLD0 * WTOTHER(0)
	B-7i	MTRAB(0) = 51.2 * PBBLD0 * WTTRAB(0)
	B-8a	$\mathrm{MPLECF[STEPS]} = \dfrac{\left[\mathrm{MPLECF[STEPS - NS]} + \left(\mathrm{UPTAKE[MONTH]} * \dfrac{\mathrm{NS}}{30}\right) + \mathrm{SUM3[STEPS]}\right]}{[1 + \{(\mathrm{NS} * \mathrm{SUM1[STEPS]})\} - \{(\mathrm{NS} * \mathrm{SUM2[STEPS]})\}]}$
	B-8b	$\mathit{SUM1[STEPS]} = \dfrac{1}{\mathit{TPLUR[MONTH]}} + \dfrac{1}{\mathit{TPLRBC2\,[MONTH]}} + \dfrac{1}{\mathit{TPLLIV[MONTH]}} + \dfrac{1}{\mathit{TPLKID[MONTH]}} + \dfrac{1}{\mathit{TPLOTH[MONTH]}} + \dfrac{1}{\mathit{TPLTRAB[MONTH]}} + \dfrac{1}{\mathit{TPLCORT[MONTH]}}$

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years;, [MONTH] = 0–84; [NS] = .iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT *(continued)*

GROUP	NUMBER	EQUATION
Compartmental Lead Masses (Solution Algorithm)	B-8c	$\mathit{SUM2[STEPS]} = \frac{1}{\mathit{TPLRBC2[MONTH]} * \left(\frac{\mathit{TRBCPL}}{\mathit{NS}} + 1\right)} + \frac{1}{\mathit{TPLLIV[MONTH]} * \left(\frac{\mathit{TLIVPL[MONTH]}}{\mathit{NS}} + \frac{\mathit{TLIVPL[MONTH]}}{\mathit{TLIVALL[MONTH]}} + 1\right)} + \frac{1}{\mathit{TPLKID[MONTH]} * \left(\frac{\mathit{TKIDPL[MONTH]}}{\mathit{NS}} + 1\right)} + \frac{1}{\left(\frac{\mathit{TOTHPL[MONTH]}}{\mathit{NS}} + \frac{\mathit{TOTHPL[MONTH]}}{\mathit{TOTHALL[MONTH]}} + 1\right)} + \frac{1}{\mathit{TPLTRAB[MONTH]} * \left(\frac{\mathit{TTRABPL[MONTH]}}{\mathit{NS}} + 1\right)} + \frac{1}{\mathit{TPLCORT[MONTH]} * \left(\frac{\mathit{TCORTPL[MONTH]}}{\mathit{NS}} + 1\right)}$
	B-8d	$\mathit{SUM3[STEPS]} = \frac{\mathit{MRBC([STEPS] - NS)}}{\left(\frac{\mathit{TRBCPL}}{\mathit{NS}} + 1\right)} + \frac{\mathit{MLIVER([STEPS] - NS)}}{\left(\frac{\mathit{TLIVPL[MONTH]}}{\mathit{NS}} + \frac{\mathit{TLIVPL[MONTH]}}{\mathit{TLIVALL[MONTH]}} + 1\right)} + \frac{\mathit{MKIDNEY([STEPS] - NS)}}{\left(\frac{\mathit{TKIDPL[MONTH]}}{\mathit{NS}} + 1\right)} + \frac{\mathit{MOTHER([STEPS] - NS)}}{\left(\frac{\mathit{TOTHPL[MONTH]}}{\mathit{NS}} + \frac{\mathit{TOTHPL[MONTH]}}{\mathit{TOTHALL[MONTH]}} + 1\right)} + \frac{\mathit{MTRAB([STEPS] - NS)}}{\left(\frac{\mathit{TTRABPL[MONTH]}}{\mathit{NS}} + 1\right)} + \frac{\mathit{MCORT([STEPS] - NS)}}{\left(\frac{\mathit{TCORTPL[MONTH]}}{\mathit{NS}} + 1\right)}$
	B-9a	$\mathrm{MRBC[STEPS]} = \frac{\mathrm{MRBC([STEPS] - NS)} + \left[\mathrm{MPLECF[STEPS]} * \left(\frac{\mathrm{NS}}{\mathrm{TPLRBC2[MONTH]}}\right)\right]}{\left[1 + \frac{\mathrm{NS}}{\mathrm{TRBCPL}}\right]}$

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years;, [MONTH] = 0–84; [NS] = .iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT *(continued)*		
GROUP	**NUMBER**	**EQUATION**
Compartmental Lead Masses (Solution Algorithm) *(continued)*	B-9b	$\text{MLIVER[STEPS]} = \dfrac{\text{MLIVER}([\mathit{STEPS}]-\text{NS}) + \left[\text{MPLECF}([\mathit{STEPS}]) * \left(\dfrac{\text{NS}}{\text{TPLLIV}([\mathit{MONTH}])}\right)\right]}{\left[1 + \dfrac{\text{NS}}{\text{TLIVALL}([\mathit{MONTH}])}\right]}$
	B-9c	$\text{MKIDNEY[STEPS]} = \dfrac{\text{MKIDNEY}([\text{STEPS}]-\text{NS} + \left[\text{MPLECF[STEPS]} * \left(\dfrac{\text{NS}}{\text{TPLKID[MONTH]}}\right)\right]}{\left[1 + \dfrac{\text{NS}}{\text{TKIDPL[MONTH]}}\right]}$
	B-9d	$\text{MOTHER}([\mathit{STEPS}]) = \dfrac{\text{MOTHER}([\mathit{STEPS}]-\text{NS}) + \left[\text{MPLECF}([\mathit{STEPS}]) * \left(\dfrac{\text{NS}}{\text{TPLOTH}([\mathit{MONTH}])}\right)\right]}{\left[1 + \dfrac{\text{NS}}{\text{TOTHALL}([\mathit{MONTH}])}\right]}$
	B-9e	$\text{MCORT[STEPS]} = \dfrac{\text{MCORT}([\text{STEPS}]-\text{NS}) + \left[\text{MPLECF[STEPS]} * \left(\dfrac{\text{NS}}{\text{TPLCORT[MONTH]}}\right)\right]}{\left[1 + \dfrac{\text{NS}}{\text{CORTPL[MONTH]}}\right]}$

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years;, [MONTH] = 0–84; [NS] = .iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT *(continued)*		
GROUP	**NUMBER**	**EQUATION**
Compartmental Lead Masses (Solution Algorithm) *(continued)*	B-9f	$MCORT[STEPS] = \dfrac{MCORT([STEPS]-NS) + \left[MPLECF[STEPS] * \left(\dfrac{NS}{TPLCORT[MONTH]}\right)\right]}{\left[1 + \dfrac{NS}{TCORTPL[MONTH]}\right]}$
	B-9g	$MPLASM[STEPS] = \dfrac{MPLECF[STEPS] * VOLPLASM[MONTH]}{VOLECF[MONTH] + VOLPLASM[MONTH]}$
	B-9h	$TOTHALL[STEPS] = \dfrac{1}{\left[\dfrac{1}{TOTHPL[MONTH]} + \dfrac{1}{TOTHOUT[MONTH]}\right]}$
	B-9i	$TLIVALL[STEPS] = \dfrac{1}{\left[\dfrac{1}{TLIVPL[MONTH]} + \dfrac{1}{TLIVFEC[MONTH]}\right]}$

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years;, [MONTH] = 0–84; [NS] = .iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

TABLE A-3. EQUATIONS OF THE BIOKINETIC MODEL COMPONENT *(continued)*		
GROUP	**NUMBER**	**EQUATION**
Blood Lead Concentration		**NOTE: Equation B-10a is computed by a cumulative loop**
	B-10a	$$BLOOD[STEPS] = \sum_{t=1}^{STEPS} \frac{MRBC[STEPS] + MPLASM[STEPS]}{VOLBLOOD([MONTH]-1)}$$
	B-10b	NS = 1/iterations per day
		STEPS = 30 / NS = iterations per month
	B-10c	PBBLOODEND([MONTH]) = BLOOD[STEPS]/STEPS

Note: Italicized variables are not parameters in the model. These variables are only intermediate variables.

[AGE] = 0–7 years;, [MONTH] = 0–84; [NS] = .iteration period expressed as a fraction of one day; [STEPS] = The time step is selected by the user. It is used in the biokinetic component of the model in combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.